Project 4.4 Bell correlations with spin-1 Bose-Einstein condensates (theoretical)

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Background:

Bell correlations are named after the scientist John Stewart Bell who first described them in 1964. They refer to correlations between the outcomes of measurements performed on two or more particles that any local hidden variable theory cannot explain. In quantum systems, these correlations are often used to demonstrate the non-classical nature of quantum mechanics and the limitations of classical theories. Nowadays, such non-trivial Bell correlations are a key element in developing quantum technologies exploiting the unique properties of quantum systems to perform tasks that are not possible using classical technologies, including quantum teleportation, quantum cryptography, and quantum computing. However, the generation and certification of many-body Bell correlated states is still a very difficult task and requires further theoretical developments.

Aim:

The main focus of this project is to explore theoretically Bell correlations with spin-1 Bose-Einstein condensates (BECs). The aim is to define protocols for the certification of Bell correlations for such systems with more than two measurement outcomes and to establish the experimentally relevant Bell tests. The project will be performed in close collaboration with the experimental group of Prof. Li You from Tsinghua University in China under the joint project SHENG. The successfully identified in the project Bell tests will be experimentally verified with ferromagnetic spin-1 BEC of rubidium-87 atoms realized in a laboratory by the Chinese team.

Requirements:

- very good knowledge of quantum physics, previous experience with ultra-cold atoms or quantum optics will be an advantage,
- numerical skills and willingness to learn new computational techniques,
- very good spoken and written English,
- master's degree in physics (or an equivalent that qualifies one for PhD studies in physics in the country of issue).

Funding:

Scholarship: grant funding of 5000 PLN per month, before subtracting obligatory employer and employee social security contributions (~15%), for 36 months. Afterwards, standard Polish PhD scholarship (about 2360 PLN/month net in years 1-2, 3640 PLN/month net in years 3-4).

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